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EIGHTH BIENNIAL REPORT
OF THE
COMMISSIONERS

OF THE

Geological and Natural History Survey

Covering the Period from
July 1, 1910, to June 30, 1912.



MADISON, WIS.

DEMOCRAT PRINTING CO., STATE PRINTER

1912

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GEOLOGICAL AND NATURAL HISTORY SURVEY.

BOARD OF COMMISSIONERS.

FRANCIS E. McGOVERN,

Governor of the State.

CHARLES R. VAN HISE, *President.*

President of the University of Wisconsin.

CHARLES P. CARY, *Vice President.*

State Superintendent of Public Instruction.

JABE ALFORD,

President of the Commissioners of Fisheries.

DANA C. MUNRO, *Secretary.*

President of the Wisconsin Academy of Sciences, Arts and Letters.

STAFF OF THE SURVEY, 1912.

ADMINISTRATION:

EDWARD A. BIRGE, Director and Superintendent. In immediate charge of Natural History Division.
WILLIAM O. HOTCHKISS, State Geologist. In immediate charge of Geology.
BESS C. BREWER, Clerk.

GEOLOGY DIVISION:

WILLIAM O. HOTCHKISS, in charge Geology.
SAMUEL WEIDMAN, in charge Areal Geology.
T. C. CHAMBERLIN, Consulting Geologist, Pleistocene Geology.
R. H. WHITBECK, Assistant, Geography & Industries.
LAWRENCE MARTIN, Assistant, Physical Geography.
VERNOR C. FINCH, Assistant, Geography & History.
EDWARD STEIDTMANN, Assistant, Limestones.
RALPH E. DAVIS, Assistant, Report on Mine Costs.

NATURAL HISTORY DIVISION:

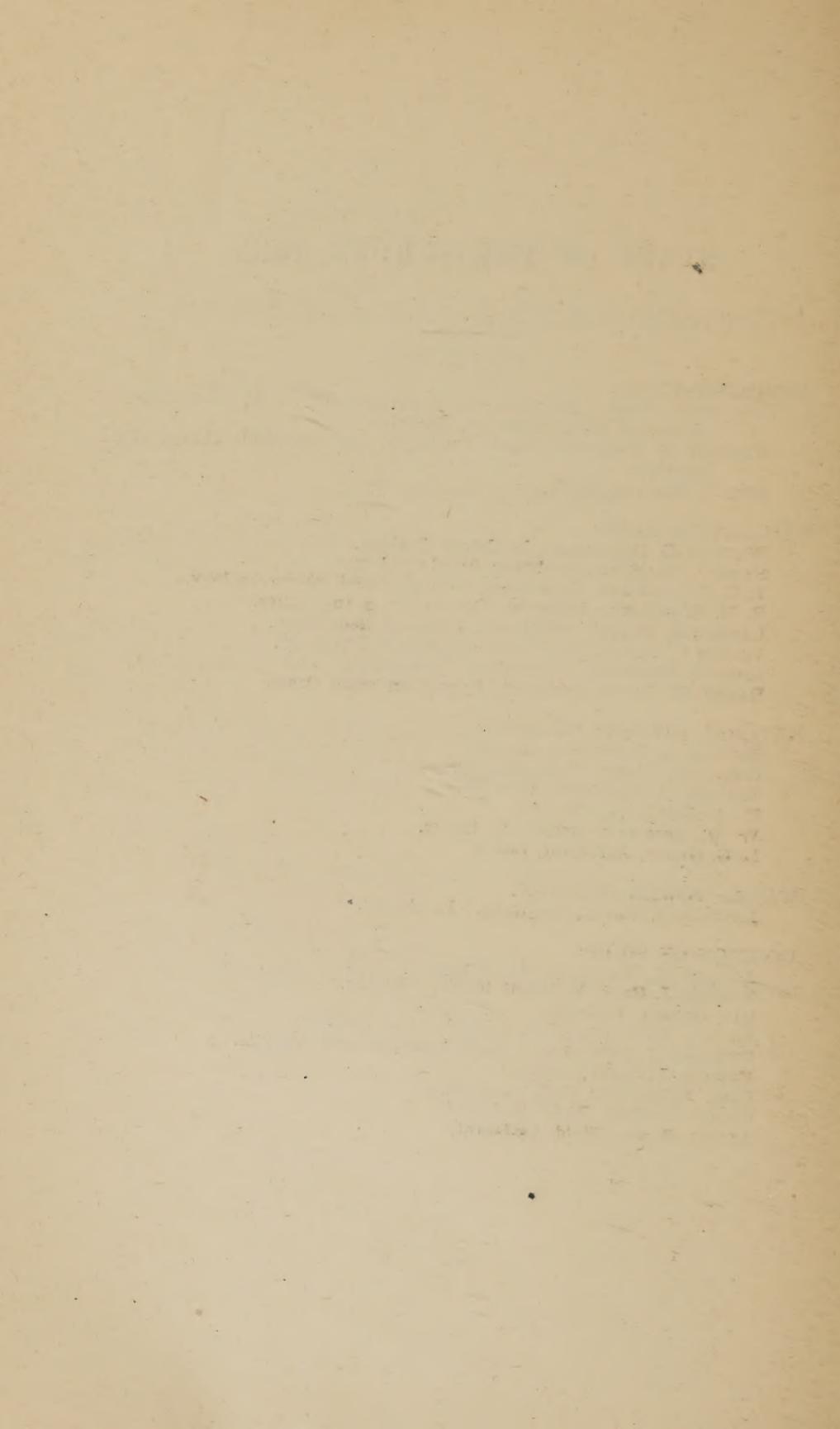
EDWARD A. BIRGE. In charge.
CHAUNCEY JUDAY, Lake Survey.
WILLARD G. CRAWFORD, Chemist.
H. A. SCHUETTE, Chemist.
W. R. BOORMAN, Assistant, Lakes.
L. G. STECK, Assistant, Lakes.

WATER POWER DIVISION:

LEONARD S. SMITH, Engineer. In charge.

DIVISION OF SOILS:

ANDREW R. WHITSON. In charge.
WARREN J. GEIB, Assistant to Mr. Whitson.
GUY CONREY, Chemist.
FRED L. MUSBACK, Field Assistant and Analyst.
THEODORE J. DUNNEWALD, Field Assistant and Analyst.
EDWARD J. GRUEL, Analyst.
CARL THOMPSON, Field Assistant.
OYVIND J. NOER, Field Assistant.
ALFRED BUSER, Field Assistant.



LETTER OF TRANSMITTAL.

COMMISSIONERS OF THE WISCONSIN GEOLOGICAL AND NATURAL
HISTORY SURVEY, MADISON.

Office of the President.

HONORABLE FRANCIS E. McGOVERN,
Governor of the State.

SIR:—I have the honor to transmit herewith the report of Dr. E. A. Birge, Director and Superintendent of the Geological and Natural History Survey, for the biennial period extending from July 1, 1910, to June 30, 1912.

During this period the work of the Survey for the highways of the state was transferred to the highway commission, of which the state geologist was made a member. This event closes one of the most successful pieces of economic work which the Survey has undertaken, and one which has resulted in the formation of a permanent organization for the care of highways and in state aid for their improvement under a single administration. The state has thus entered on an improvement of the greatest value to its people under conditions which promise wise and efficient expenditure of the money of the people. Apart from this material work of the Survey during the past two years there is little which demands comment, beyond the statements which are made in the report of the director. I desire, however, to call especial attention to the recommendations made for the enlargement of the work of the Survey in the direction of the preparation of topographical maps. The development of the state in many directions, especially in the improvement of water powers, the carrying out of drainage projects, and the development of a highway system for the state demands the preparation of these maps as rapidly as possible. A good topographical map cannot be prepared rapidly, but is necessarily the work of a considerable number of years. The state should have begun this work earlier, as has been urged in earlier reports of

this Survey, but every year's delay hereafter is quite sure to result in financial losses to the state much greater than the cost of a topographical survey.

I would call attention also to the progress of the soil survey and to the prospect that if it is finished on the scale on which it was planned it is likely to be completed within the time assigned by the Survey when the state was asked to establish it. I recommend to the attention of the legislature a consideration of the proposal that the survey be made more detailed in the northern portion of the state. No attempt should be made to carry out the survey in the woods with the detail which is given to the cultivated areas of the state, but the rapidity with which settlement is going on and is likely to continue in the northern part of the state may well call for a survey somewhat in advance of the immediate necessities of settlement.

Very respectfully yours,

CHARLES R. VAN HISE,

President.

REPORT OF THE DIRECTOR OF THE SURVEY.

To the Commissioners of the Geological and Natural History Survey:

GENTLEMEN:—I submit herewith my eighth biennial report as Director and Superintendent of the Wisconsin Geological and Natural History Survey, extending from July 1, 1910, to June 30, 1912.

The income for the Survey has differed in the two years covered by this report. In the fiscal year 1910–11 the income was as follows:

General appropriation	\$10,000
Highways	10,000
Soil Survey	10,000

The legislature of 1911 transferred the work of the Highway Division from this Survey to the newly created highway commission, and gave the Survey a single appropriation of \$20,000 annually for the rest of its work. This left the income of the Survey substantially unchanged. The result has been that no important new lines of work have been started, although much progress has been made on the lines already undertaken.

The Survey has also received aid from the United States bureau of fisheries, amounting to \$600 per year, to assist the field work on the lakes of the state. The Wisconsin commissioners of fisheries have also given aid, chiefly used in collecting the Wisconsin fishes of commercial value. Personal gifts have been received, amounting to \$935.

Determination of the direct connection of the Survey with the care of the highways is the most important event of the two years. When Mr. Hotchkiss became a member of the staff of the Survey in 1906 he made it one of his first duties to take up the matter of roads. A bulletin was issued on rural highways in 1907, which had much effect in promoting wise legislation on the subject. Highway legislation was considered by the legislatures of 1907 and 1909, but it was not until 1911 that a bill

was finally passed, establishing a highway commission and placing this work on a permanent basis. Thus during five years the Survey had charge of whatever work was done by the state for the improvement of highways. The work of this division of the Survey, under the charge of Mr. Hotchkiss, contributed greatly to reaching the fortunate result of the establishment of a highway commission. I question whether the state has ever expended money with more immediate and large returns than that expended on highways through this Survey.

The act establishing the highway commission made the state geologist, Mr. Hotchkiss, one of the commissioners, and the duties of this position have occupied a large portion of his time.

With the close of the year 1910-11 the director turned over to the state geologist, Mr. Hotchkiss, the detailed work of administration of the Survey, and the clerk of the geology division became clerk of the Survey. At present, therefore, the active work of the Survey is carried on in three divisions: geology in charge of Mr. Hotchkiss; natural history in charge of the director; and soils in charge of Professor Whitson. The general supervision and administration remains with the director, but the details of administration, as well as the immediate charge of geology are committed to Mr. Hotchkiss. This change was the more easily made because the immediate administration of the soils has always been in the hands of Professor Whitson, and by far the larger portion of the remainder of the work of the Survey is in the division of geology. In giving up these detail duties of administration, the director also gave up the salary which he has received from the Survey.

I. PERSONNEL OF THE SURVEY.

The following table shows the organization of the Survey, with the names of the persons who have been employed during the past two years. The amount of money paid to each person, including compensation and allowances for field expenses, is included in the report of the secretary of state.

ADMINISTRATION:

EDWARD A. BIRGE, director and superintendent. In immediate charge of natural history division.

WILLIAM O. HOTCHKISS, state geologist. In immediate charge of geology and highway divisions.

F. G. SANFORD, clerk, 1910-11.

BESS C. BREWER, clerk, 1911-12.

GEOLOGY DIVISION:

WILLIAM O. HOTCHKISS. In charge.
 SAMUEL WEIDMAN, geologist. Areal geology.
 F. T. THWAITES, 1910-11. Report on Lake Superior sandstone.
 R. H. WHITBECK, 1911-12. Report on geography and industries.
 LAWRENCE MARTIN, 1912. Report on physical geography.
 EDWARD STEIDTMAN, 1912. Report on limestones.
 F. W. HUELS, 1910-12. Report on peat.
 C. L. DAKE, 1910, assistant, Florence iron district.
 HYRUM SCHNEIDER, 1910, assistant, Florence iron district.
 HARMON LEWIS, 1910, assistant, Florence iron district.
 E. F. BEAN, 1911, assistant, Florence iron district.
 F. E. WILLIAMS, 1911, assistant, Florence iron district.
 VOLNEY G. BARNES, 1911, compassman, Florence iron district.
 RUSSELL HANCHETT, 1911, compassman, Florence iron district.
 ROBERT HANKOHL, 1911, compassman, Florence iron district.
 H. A. WRIGHT, 1910, compassman, Florence iron district.
 J. BERGLUND, 1911, cook, Florence iron district.
 E. H. TOOLE, 1910, assistant Lake Superior sandstone.
 FRED GILLIES, 1911-12, draftsman.
 O. G. WARD, 1911, draftsman.
 F. W. LABRAM, 1912, draftsman.
 J. K. LIVINGSTON, 1912, draftsman.
 C. W. GATES, 1911, draftsman.
 A. B. HARDIE, 1912, draftsman.
 R. C. WILLIAMSON, 1911, stenographer (Weidman).

NATURAL HISTORY DIVISION:

EDWARD A. BIRGE. In charge.
 CHAUNCY JUDAY. Lake survey.
 H. A. SCHUETTE, 1911-12.
 W. R. BOORMAN, 1911-12.
 L. G. STECK, 1911-12.
 F. PINKERTON, 1910.
 S. D. NOURSE, 1910.
 W. G. LYTHE, 1911.

HIGHWAY DIVISION, 1910-11.

WILLIAM O. HOTCHKISS, chief of division.
 A. R. HIRST, highway engineer.
 M. W. TORKELSON, bridge engineer.
 H. J. KUELING, assistant engineer.
 S. P. HALL, assistant engineer.
 F. M. BALSLEY, road expert.

WATER POWER DIVISION:

LEONARD S. SMITH. In charge. No work done during 1910-12.

SOILS:

A. R. WHITSON. In charge.
 F. L. MUSBACK, 1910-12.
 E. J. GRAUL, 1910-12.
 T. J. DUNNEWALD, 1910-12.
 GUY CONREY, 1911-12.
 CARL THOMPSON, 1912.
 O. J. NOER, 1912.
 W. J. GEIB, 1911-12.
 L. R. SCHOENMANN, 1910.
 LOUISE JAHNS, 1910.

A. H. MEYER, 1910.
 L. F. AUGSPURGER, 1910.
 C. A. LECLAIR, 1910-11.
 W. E. BLAIR, 1910.
 O. I. BERGH, 1910.
 S. B. DUDGEON, 1910.
 P. P. PETERSON, 1910.
 O. E. BAKER, 1910.

II. FINANCIAL STATEMENT.

In the following table I have summarized the expenditures of the Survey according to departments, thus indicating the main directions in which the money appropriated by the state has been expended. The result is as follows:

Secs. 392 j—1,—2,—3,—4; 392k, 392k—1 and 392l of the Statutes	1910-11	1911-12
Administration.....	\$849.00	-\$638.51
Areal geology.....	3,090.35	2,747.18
Economic geology.....	4,052.42	5,063.57
Highways.....	9,945.56
Lake biology.....	2,466.51	2,707.24
Peat.....	50.00	4.20
Physical geography.....	10.55
Soils.....	9,370.85	8,096.93
Revision of bulletin.....	206.73
	\$29,631.42	\$19,268.18

The sums as given in the statement above do not agree with the totals from the table furnished by the secretary of state whose report should be consulted for the details of expenditures. The figures in my report refer to claims audited at this office during the period covered by the report, and always include some claims at the close of the year not included by the secretary of state and omit at the opening of the year others included by him. The secretary of state also includes in his report items paid from the general fund for printing and engraving.

III. WORK OF THE SURVEY.

During the past biennial period no work has been done on water powers and the work on highways was transferred to the highway commission in June, 1911. The activities of the Survey, therefore, come under four divisions:

1. Geology, in charge of State Geologist Hotchkiss.
2. Natural history, in charge of Director Birge.
3. Highways until July 1, 1911, in charge of Mr. Hotchkiss.
4. Soils, in charge of Prof. A. R. Whitson.

A. GEOLOGICAL WORK IN IMMEDIATE CHARGE OF
W. O. HOTCHKISS.

1. *Peat:* In the biennial report for 1909-1910 it was stated that a report on the peat resources of the state was nearly completed and an outline of the report was given. Owing to the fact that Mr. F. W. Huels, the author, took up other employment in which it has been impossible for him to give time to the completion of the report, it has not been possible to send this to press, but it is believed that it can be finished and printed during the coming fiscal year.

This report will be of much value as the Survey is in frequent receipt of requests for information from persons interested in the development of peat in the state. One large company is very seriously considering the location of an extensive plant for the manufacture of peat paper in Wisconsin.

2. *New Geological and Road Map:* The information for this map was put in the hands of the engraver in August, 1910, but owing to delays for which this Survey was not responsible, the map is just ready to issue. The legislature of 1911 passed a joint resolution instructing the printing commission to print sufficient copies so that the state superintendent of public instruction could furnish one to each school in the state. The map shows with much detail the various geologic formations of the state, so far as at present known, and in addition shows all the roads. Great care has been taken to show these roads as accurately as possible. The main roads are shown by a heavy red overprint. This map will be of great value to automobilists and other tourists, and will assist in helping to draw to this state

much of this profitable traffic. No state in the Mississippi valley has such attractions in the way of climate and beautiful scenery as has this, and no state has a better road map to make tourists travel safe and easy.

The map is on the scale of six miles to one inch, so that a township is one inch square. The size of the map is 52 by 54 inches. In one corner are given the elevations of various important features, as lakes, hills and rivers. In another corner is given a description of the rocks. This is written in simple non-technical terms and gives the economic products derived from each of the various formations, as well as their general character and thickness. A brief geological history of the state is also given, in which the origin of the various rock formations and the present shape of the surface is outlined. No state has ever published such a complete, accurate map and this one should prove very useful both for general use and for educational purposes.

3. *Sandstones of the Wisconsin Coast of Lake Superior:* In July, 1910, Mr. F. T. Thwaites began the field work for a report on "The Sandstones Along the Shore of Lake Superior." His report is now in press and will appear as Bulletin XXV, Scientific Series No. 8. The results of this work make a valuable contribution to our knowledge of the origin, age, and structure of the rocks studied. For over a generation there has existed a controversy as to the age of the flat lying brown sandstones of this region and their relation to the steeply tilted sediments to the south of them. Mr. Thwaites has gone over the evidence very thoroughly and reached the conclusion that the tilted and horizontal rocks are parts of a conformable series.

This report is in eight chapters as follows:

Introduction:

Chapter	I. Topography of Wisconsin Coast of Lake Superior.
"	II. Previous Investigations.
"	III. The Bayfield Sandstone Group.
"	IV. Orono Group and Older Formations, and the Extension of the Sandstone Groups in Minnesota.
"	V. The Relation of the Bayfield and Orono Groups.
"	VI. The Contact of the Bayfield Group with the Traps.
"	VII. Structure of the Wisconsin Coast of Lake Superior.
"	VIII. Conclusions.

4. *Statistics of Wisconsin Mineral Production:* For the two years covered by this report the State Survey has been coöperating with the United States geological survey in collecting sta-

tistics of Wisconsin mineral production. In this work a great mass of valuable information has been obtained at practically no expense to the state.

5. *Survey of the Florence Iron District:* Late in June, 1910, Mr. Hotchkiss began a geological survey of the iron district in Florence county. He was assisted in the field that year by C. L. Dake, Hyrum Schneider, and Harmon Lewis. The field work was continued until about October 20. During the following winter and spring it was impossible for Mr. Hotchkiss to give any time to preparation of any part of his report owing to the demands on his time due to the highway legislation pending in the legislature. Early in July, 1911, field work was resumed, the field assistants being E. F. Bean, F. E. Williams, Russell Hanchett, and Robert Haukohl. Field work was continued until September 18.

This district has two of the oldest mines in the Menominee range, but owing to the complicated nature of the geology no new mines have been discovered. Persons who wished to carry on explorations had to proceed blindly with the result that failure to find ore soon discouraged them. It was hoped that it might be possible by a careful geological survey to remedy this condition and furnish information that would result in further and more successful exploration for iron. It was also hoped that the northwestward continuation of the Florence district might be found to turn southwestward and thus bring the iron-bearing rocks back into Wisconsin and demonstrate the fact that large areas in the little known (geologically) northern counties are probably underlain by iron-bearing rocks.

Fortunately both these hopes have been realized even before the report could be written, for field parties of the Michigan geological survey have already traced distinct magnetic belts southwestward to the Wisconsin boundary and explorations are now in progress along their extension into this state.

Mr. Hotchkiss was successful in working out the difficult structure of the Florence district proper and his report will be of much value as a guide to future development in that region. Aside from the considerable part consumed by administrative work, by correspondence and consultation with persons interested in the geologic resources of the state, and by his connection with the state highway commission, all of Mr. Hotchkiss' time since the close of the field season in 1911 has been given

to the preparation of the report on the "Florence Iron District." It is hoped that it may be sent to the printer before this report is issued.

The report as outlined is as follows:

Chapter	I.	Introduction.
"	II.	History and Ore Production.
"	III.	General Geology.
"	IV.	Magnetic Observations.
"	V.	Iron Formations and Ore Deposits.
"	VI.	Other Huronian Sediments.
"	VII.	Igneous Rocks, Tuffs and Green Schists.
"	VIII.	Structure and Correlation.
"	IX.	Physiography and Soils.
"	X.	Summary of Results.

6. *Limestone Investigations:* In coöperation with the state highway commission, which bears a small part of the expense, a study of the limestones of the state is being made. Mr. Edward Steidtmann began the work in May, 1912, and will complete the field work by the end of September. The report on this work will be written during the following winter and will appear as a joint bulletin by Mr. Hotchkiss and Mr. Steidtmann on the "Limestone Road Materials of Wisconsin." A large number of samples have been taken. Nearly two hundred will be subjected to chemical analyses to determine the lime, magnesia, silica, iron, alumina and phosphorus content. A larger number have been sent to the United States office of public roads, which is coöperating in the work by making tests as to the quality of the stone for road purposes. Representative sets of specimens have been collected for the highway commission and for this Survey.

This work will give a large amount of valuable detailed information on the road building materials of the state which will be particularly useful on account of the vast sums now being expended in the construction of stone roads.

After preparation of the first report it is planned to prepare another report based on this field work which will deal with the use of limestone in other industries and with some of the more particularly scientific phases of the subject.

7. *Costs of Lead and Zinc Mining:* At the request of the mining men of the lead and zinc district, an investigation of mining costs was begun early in 1912. This work was undertaken by Mr. Ralph Davis, director of the mining trade school at Platteville, who agreed to give his services as the portion to

be borne by the mining trade school, the Survey to pay the field expense and the clerical work of tabulating the results and preparing the report. Many of the detailed confidential statements of cost have already been received from the mine operators and it is hoped that Mr. Davis will have his report ready for the printer some time during the winter.

8. *Educational Bulletins:* In the last biennial report there was mentioned a plan to publish a general volume on the geology of Wisconsin, written in simple, non-technical terms, as one of the Survey's educational series of publications. It was planned that various persons familiar with particular phases of the geology of the state should each contribute a chapter on his special subject. It was found impracticable, however, to withhold the whole report until all the chapters could be written and so the plan was changed and each separate phase of the report will be published as an educational bulletin. Those parts in press or soon to be ready for printing are the bulletins on "Geography and Industries"; "Physical Geography of Wisconsin"; "Geography and History"; and "Climate of Wisconsin"; all of which it is hoped will be issued during the coming winter.

The report on the "Geography and Industries of Wisconsin" has been prepared by Prof. R. H. Whitbeck of the University of Wisconsin. This is now in press and will be issued as one of the educational bulletins of the Survey. The bulletin is written specially for the use of teachers, and high school students, but will be of much interest to others as well. It discusses the relation between the physical features of the state and the industrial development. Separate chapters discuss various features as follows:

1. General Principles.
2. Brief Outline of Climate.
3. Brief Outline of Physiography.
4. Forests and Wood Using Industries.
5. Agriculture, Dairying and related Industries.
6. Mining and Quarrying.
7. Transportation.
8. Manufacturing.

The bulletin on the "Physical Geography of Wisconsin" has been prepared by Prof. Lawrence Martin of the University, and is nearly ready to go to press, the first six chapters being en-

tirely finished and the last three being partly finished. The outline of the report by chapters is as follows:

Chapter I. Brief Statement of Geology, Climate, Topography, Hydrography, and the place of Wisconsin in the Physical Geography of the United States.

Chapter II. The Northern Highland.
Geological Provinces of the State.
The Northern Highland.
Effects of Glaciation.

Chapter III. The Lake Superior Lowland.
General Description.
Glacial Modifications.

Chapter IV. The Central Plain.
The Belted Plain.
The Central Plain.
Changes Due to Glaciation.

Chapter V. The Eastern Ridges and Lowlands.
Location and General Geography.
Topography Controlled by Cuestas.
Magnesian Limestone Cuesta.
Green Bay—Winnebago Lowland.
Niagara Cuesta.

Chapter VI. Glaciation of Eastern Wisconsin.
Topographic Features Due to Glaciation.
Surface Feature Due to Deposition.

Chapter VII. The Western Uplands.
The Two Cuestas.
The Upland of Magnesian Limestone and Potsdam Sandstone.
The Baraboo Range.
The Southwestern Upland of Galena-Trenton Limestone.
Glaciation of Northwestern Section.
The Driftless Area.
Windwork During and Since Glacial Time.
Work of Underground Water in Western Upland.

Chapter VIII. The Rivers and Lakes of Wisconsin.
General Relationship of Rivers.
The Wisconsin River.
The Mississippi River.
The Black, Chippewa and St. Croix Rivers.
The Rock and Sugar Rivers.
The Fox River System.
The Menominee River.
The St. Louis, Nemadji, Brule and Montreal Rivers.
The Lakes of Northern and Northwestern Wisconsin.
The Lakes of Eastern and Southeastern Wisconsin.
The Swamps.

Chapter IX. Coasts of Wisconsin.
General Relationships.
Lake Michigan and Green Bay.
Lake Superior.

Appendix. Suggestions as to Field Tps in Typical Areas of the States

An educational bulletin on the "Geography and History of Wisconsin" is in preparation by Mr. V. C. Finch, an assistant in the geological department of the University, who has made a special study of the relationships of geography and history.

This bulletin is outlined as follows;

- Section I. The Period of French Domination.
 - Relation of Great Lakes to Opening of the State.
 - Influence of Interior Water Routes.
 - Fur Industry and French Settlement.
- Section II. The period of American Domination.
 - 1. Development of the Southwestern Part of the State.
 - Influence of Lead Mines.
 - Influence of Mississippi River.
 - Influence of Topography.
 - 2. Development of the Southeastern Part of the State.
 - Influence of the Great Lakes.
 - Origin of Settlers and Geographic Influences of their Migration.
 - 3. Development of the Northern Part of the State.
 - Influence of the Forests.
 - Influence of Geology and Minerals.
- Section III. The Recent Period of Development of the State.
 - Geographic Influences in the Development of Agriculture.
 - Geographic influences in the Development of Transportation.
 - Geographic influences in the development of Cities and Industries.

An educational bulletin on "The Climate of the State" is being prepared by Mr. Eric Miller, in charge of the Madison weather observatory of the United States department of agriculture. This report is not sufficiently advanced in preparation to give a detailed outline of its contents, but it is hoped that the author will be able to complete it at an early date.

B. WORK CARRIED ON BY DR. WEIDMAN.

1. *Soil Surveys:* During the field season of 1910 the work of Dr. Weidman consisted mainly in completing the soil survey of Northwestern Wisconsin. The mechanical analyses (determination of physical texture) of the various soils, made by the United States bureau of soils, were completed in the early part of the season and a final correlation of the soils of the area was then made possible. The soil map was completed and sent to the engravers in September, 1910.

The report on the soils was completed during the winter of 1910-11 and was printed in July 1911.

The report on the soils, Bulletin No. 23 "Reconnaissance Soil Survey of Part of Northwestern Wisconsin," by S. Weidman, assisted by E. B. Hall and F. L. Musback, contains 102 pages and a colored soil map on the scale of three miles to the inch. The area surveyed, indicated on the accompanying map of the state (fig. 1) includes nine counties, Eau Claire, Chippewa,

Rusk, Barron, Dunn, Pepin, Pierce, St. Croix and Polk, having a total area of about 6,800 square miles.

The report describes the general geographic and geologic features of the area, the detailed descriptions of the soils, and a resumé of agricultural conditions. In general character it is very similar to Bulletin No. 11, "The Soils and Agriculture of North Central Wisconsin." It is more complete, however, than the latter on account of additional information made available by the appropriation for the soil survey of the state.

During December, 1911, the state edition of the "Soil Survey of Marinette County," Bulletin 24, Soil Series No. 1, was issued. This report by S. Weidman of the Wisconsin Survey and P. O. Wood of the bureau of soils, United States Department of Agriculture, contains 44 pages and a soil map on the scale of three miles to the inch. This soil survey report was first printed by the United States department of agriculture in July, 1911, and in accordance with the plan of the coöperative surveys, the state edition was printed as soon thereafter as convenient.

2. *Geology of the Northwestern Area:* The report on the "Geology of the Northwestern Area," the geological work having been started at the same time as the survey of the soils of the area, is being completed as rapidly as possible. Additional field work, however, is required in certain parts of the area and in adjacent territory in order to finish the work in a satisfactory manner. The northwestern part of our state adjacent to Minnesota contains many complicated geological features of much scientific importance, and these are being investigated with considerable care. The area contains rock formation ranging from the oldest Pre-Cambrian to the youngest Pleistocene series.

The Pre-Cambrian is represented by the Archean granites and greenstones of Chippewa and Rusk counties, and by the Keweenawan trap and quartzite in Polk and Barron counties. The Paleozoic formations are represented by the Potsdam sandstone, the Lower Magnesian limestone, the St. Peter sandstone and the Trenton limestone. The Pleistocene formations include the glacial and alluvial deposits and loess.

The glacial geology of the area is particularly important as the region happens to be the common meeting ground of the ice sheets that advanced southward into the northern United States from the two centers of glacial development, namely the

two centers east and west of Hudson Bay, and known respectively as the Labrador and the Keewatin centers of glacial radiation.

In Northwestern Wisconsin there were apparently five glacial epochs widely separated with respect to time, and each epoch is characterized by a distinct drift formation deposited by ice sheets which invaded the area contemporaneously from the northeast and from the northwest centers of glaciation. In the survey of the glacial formations Dr. Weidman is coöperating informally with Mr. Frank Leverett of the United States geological survey, who is engaged in a survey of the glacial geology of Minnesota.

It is desirable that at least the more important geological problems be adequately investigated and described in the geological report, as they are not only of scientific value and interest to the people of Wisconsin, to the schools, teachers and general readers, but also to many scientists and students outside the state.

3. *Work for the State Park Board:* In July, 1910, Dr. Weidman was instructed to investigate the Baraboo quartzite with reference to available sites for garnister quarries for the purpose of assisting the state park commission in the case in litigation, *The State of Wisconsin vs. The American Refractories Company*. About three weeks in 1910 were spent in carrying out the required preliminary investigation. During the summer of 1911 additional work of four or five weeks was required in order to prepare for the final trial held in September, 1911. In this coöperative work with the park commission, the entire expense of the preliminary work done in 1910 was paid out of the Survey funds, but in the final work in 1911 only the services and traveling expenses of Dr. Weidman were paid by the Survey and all other expense involved was paid by the park commission.

4. *Report on Water Supplies:* During the present biennial period work on the report of "Water Supplies of the State" has been practically completed and will be ready for the printer in December, 1912. Collection of data for a report on underground water supplies was begun in 1904 by A. R. Schultz for the United States geological survey. Later this data was turned over to the state Survey for publication and during the past three years Dr. Weidman has given such time as was available

to the revision of Mr. Schultz's report and the compilation of additional data to include all sources of water supplies used in the state.

In its completed form the report will be of great value to boards of health of the state as it will contain all available data in regard to public water supplies, sources of the water supply and the mineral composition of our underground and surface supplies. The report will contain about 300 pages and will be issued under the joint authorship of Mr. Weidman and Mr. Schultz.

C. NATURAL HISTORY SURVEY, IN CHARGE OF DIRECTOR BIRGE.

1. *Lakes:* The work on the lakes has been under the immediate charge of the director, with Mr. Juday as permanent assistant. Several other persons have given temporary assistance from time to time.

The field season of 1910 was chiefly given to completing the report on the "Dissolved Gases of the Water of the Inland Lakes." This report was issued in 1911 as Bulletin No. XXII. Its contents were stated in the last biennial report and need not be repeated here.

The report on lake temperatures—the second important investigation on lakes—is still in preparation. In April, 1911, a Callendar sunshine receiver and recorder were installed by the University of Wisconsin at the office of the United States weather bureau in Madison. This instrument gives automatically a continuous record of the amount of energy received from the sun and sky. The records have been cared for by Mr. Eric Miller, local forecaster, United States weather bureau. In July, 1912, the United States weather bureau replaced the recorder which the Survey had borrowed from the University with an instrument of their own. Daily observations of temperature on Lake Mendota have been made, and by comparing these with the sunshine records it is possible to determine the amount of energy stored up by the lake as compared with that received by its surface, and the rate at which energy is absorbed in the spring and given off in the autumn.

In 1912 an instrument was constructed for measuring the rate at which solar energy is absorbed as it penetrates the water of the lake. It consists essentially of a thermopile and galvano-

meter and was designed by Professor Mendenhall of the department of physics in the University, and made by Mr. Foerst, the mechanician of the department. These new instruments and observations are delaying the completion of the temperature report.

In the early years of the Survey the hydrography of some fifty lakes and lakelets of Southeastern Wisconsin was ascertained. The results were published in a series of separate maps. Mr. Juday has now brought together all information at hand regarding the area, depth, etc., of the inland lakes of the state and these are to be published as a separate report. The maps of the lakes which have been surveyed will be issued on a larger scale. These are now in the hands of the engraver.

The main work of the Survey during the seasons 1911 and 1912 has related to the chemistry of the plankton, and to this Mr. Juday has given most of his time. The studies deal especially with the food value of the vast number of microscopic organisms in lakes, known collectively as the plankton. These living organisms play an important part, either directly or indirectly, in the food supply of most fishes, and information concerning the quantity of this plankton, and its value as a food is of great importance from the standpoint of fish culture. We have fairly accurate information concerning the productivity of the soil but practically nothing is known concerning the productivity of lake waters. This work has, therefore, been undertaken for the purpose of obtaining knowledge on which more accurate estimations on the productivity of lakes may be based. It has so far been confined to Lake Mendota.

Through private aid, the Survey has had the free use of a gasoline launch, whose engine was used in 1911 to pump the water from which the plankton was strained. In 1912 a small portable gasoline engine was installed, which operates the pumps. These draw water from different depths through hose, so that a fair sample of a column of water is obtained extending from surface to bottom. This is strained through a fine silk net and the organisms are retained for chemical analysis.

Pumping has been carried on regularly twice a week during the seasons of 1911 and 1912 from the time that the ice leaves the lake until it freezes again. The two collections for each week have been combined for purposes of analysis. Each such sample represents the results of straining from 10,000 to 17,000

liters (2,500-4,200 gallons) of water. Chemical analyses have been made, both of the organic substances and the ash from these collections.

The Survey has been aided, as in former years, by the United States bureau of fisheries, and our field work has been correspondingly larger and more complete. The Wisconsin fish commission has also given aid which has been chiefly devoted to the collection of fish. The Survey extends its thanks to both of these organizations for aid indispensable in reaching its results.

The United States bureau of fisheries defrayed the expenses of Mr. Juday and the director for the month of August, 1910, in an investigation of the lakes of Central New York. Ten lakes from Otisco on the east to Conesus on the West, were studied with reference to dissolved gases, etc., in the same way as those of Wisconsin have been investigated. These lakes are much larger and deeper than those of Wisconsin and conclusions of much importance were drawn from their study. They carried our observations up to lakes nearly forty miles long and six hundred feet deep. In Wisconsin, Green Lake, our deepest lake, is seven miles long and two hundred and thirty-two feet deep, and no larger lake in Wisconsin has any considerable depth.

2. *Fish.* This department is in charge of Mr. Wagner. During the summers of 1910 and 1912 no additions were made to the collection, largely because no suitable person for field work was available. In August of 1911 the Survey was fortunate in securing the services of Mr. J. N. Loshinski of the zoological staff of Ripon College, and he was in the field for somewhat over a month, examining various lakes which were known to contain some form or other of salmonids. He added a considerable number of valuable specimens to our collection. An expedition which Mr. Wagner made into Northeastern Minnesota gave an opportunity to add to our knowledge of the most important whitefish of our region, *Coregonus clupeiformis*, which is still too little understood.

During the two years Mr. Wagner has devoted some time to the study of the collections, especially of the salmonids. Increasing duties, however, in connection with the construction of the new zoological laboratory, and the very crowded condi-

tion of all parts of Science Hall made such work difficult and slow.

The collection has now been moved into the new building and is being arranged in orderly manner. As soon as the necessary work of placing the new quarters in order is over, it is hoped that work on the collection may go on more rapidly and that the report on the Salmonidae at least may be finished this winter.

D. HIGHWAY DIVISION IN CHARGE OF MR. HOTCHKISS.

The work of this division was carried on exactly as described in the last biennial report, up to June 30, 1911. The legislature of 1911 created a state highway commission which in July took over the work started by the highway division. The state geologist was made a member *ex officio* of this commission. Much of Mr. Hotchkiss' time was given to the organization of this body and getting the work under way. All the employes of the highway division and its correspondence and records were turned over to the new body.

During and for several months before the legislative session of 1911 practically all of Mr. Hotchkiss' time was given over to consultation with members of the legislature and committees and to the study of state highway laws and the suggestion of plans for the state highway law in Wisconsin.

During the year from June 30, 1910, to June 30, 1911, the work of the highway division was carried on under the direction of W. O. Hotchkiss as chief, with A. R. Hirst as highway engineer, M. W. Torkelson as bridge engineer, H. J. Kuelling as assistant engineer, and Miss Bess C. Brewer as *chief* clerk.

The highway work which this Survey organized has been of great benefit to the state. It has resulted in the education of the people of the state to the benefit of good roads, taught them much of the principles of constructing good roads, and so favorably impressed them that the people of the towns and counties levied taxes and asked for state aid thereon of more than \$100,000 over what the legislature provided for the first year of work under the new state aid law. In the year 1912 nearly \$1,500,000 was economically expended on state aid roads as a direct result of the original work of this Survey, and in

1913 the amount will be nearly double that sum. The value of a survey such as this, with a moderate appropriation to study in a scientific manner the needs of the state and its resources available to meet these needs, cannot fail to be strongly impressed on one who studies this situation carefully.

E. SOIL SURVEY, IN CHARGE OF PROFESSOR WHITSON.

1. *The Reconnoissance Survey of the Northwestern Portion of the State*, including Douglas, Bayfield, Burnett, Washburn, Sawyer, and a large part of Ashland counties, has been pushed as rapidly as possible and the field work will be completed in October of this year. Mr. Musback, who is in charge of this area, has been assisted by Mr. T. J. Dunnewald and Mr. Carl Thomson. The preparation of the map of this area is now in progress, a large part of the analytical work has been done and it is hoped that the report can be finished and published during the coming winter and spring. The large demand for accurate information on the soils of this section of the state, which is being rapidly developed, has made desirable the pushing of the work in this area at some sacrifice to the work in other portions of the state. The very slight knowledge of the state at the time the general map of the soils of Wisconsin was published by Professor Chamberlin in 1882 makes it all the more important that accurate information be available to prospective settlers. Fourteen different types of soil have so far been mapped and while these types as now being mapped are general and will not be given the same names as the specific types which would be mapped in the detailed survey, the work being done at this time will very greatly lessen the amount of work necessary in the detailed survey which will be desirable after a period of ten to fifteen years.

2. *The Reconnoissance Work in the Northeastern Area*, including Forest, Florence, Shawano, Oconto, and the eastern portion of Langlade counties, has been begun this season and all of Forest and probably most of Florence counties will be mapped. Probably two years additional work will be necessary to complete this area. The State Survey is coöperating in this area with the bureau of soils as it is in the detailed areas. The survey of this region will be helpful, especially in determining which lands are of agricultural value and which could,

with greater profit, be devoted to forestry purposes. The survey of this area with the publication of the maps will undoubtedly be a great aid in the settlement of that section. A large part of the area has soils of excellent physical character.

3. *The Northcentral Area*, which will include Iron, Vilas, Oneida, a large part of Price, and the eastern portion of Ashland counties, includes the area in which the forest reserve is being developed. While the Survey will ultimately publish a soil map of this area similar to that of the northwestern and northeastern areas, we are at present only assisting the state forester in determining the agricultural value of certain portions of this area. It is impossible to say now just how soon the complete mapping of this area can be undertaken.

4. *Detailed Survey.* During the fiscal period ending July 1912 the detailed soil survey has been completed in Fond du Lac, Juneau, La Crosse, Kewaunee, and Columbia counties and the work begun in Buffalo, Dane, and Jefferson counties. In all approximately 3375 square miles were mapped in the detailed survey during the past two-year fiscal period. In carrying out the policy of pushing the reconnaissance work in the northern part of the state it may not be possible to continue this rate of work in the detailed area during the next years, but after the reconnaissance work has been completed, even more rapid progress can be made in the detailed area so that we have every reason to believe that the original estimate of time for the mapping of the entire state will be sufficient.

We have now distinguished and are mapping eighty-five different types of soils in the detailed work classified into seventeen series. A considerable number of these types have been made on bases other than those of texture and chemical composition, such as topography, drainage conditions, and degree of stoniness. These are factors of all-controlling importance in agriculture and while their mapping has not been customary in the work of other soil surveys, it is of such importance in Wisconsin in particular that the establishment of the new soil types is fully warranted. From one to four chemical analyses of the soils of each type mapped in each county have already been completed and since in most cases each type occurs in several counties it is evident that we shall have from twenty to fifty analyses of each important type mapped in the state, a

number sufficient to determine accurately its chemical composition.

5. *Personnel.* The general direction of the Survey has been in charge of A. R. Whitson. F. L. Musback has been in charge of the field work of the northwestern area and the preparation of the map of that area.

Mr. Guy Conrey is chemist of the soil survey and field assistant.

Mr. T. J. Dunnewald as field assistant has been especially concerned with the mapping of the rougher portions of the state along the Mississippi river and its tributaries in Iowa, La Crosse, and Buffalo counties.

Mr. Roy Schoenmann and Mr. A. H. Meyer, who began work on the Survey at its initiation in 1909, continued as field assistants during the field season of 1910-11, but accepted positions with the bureau of soils of the United States department of agriculture in the fall of 1911. They were given assignments in Wisconsin during the field season of 1912, so that their services have been retained by the state, though under the direct employment of the government.

Mr. Otto Bergh, who was field assistant in 1910, resigned his position to accept the position of teacher in the Bemidji Minnesota High School.

Mr. E. J. Graul was field assistant during the field season of 1911 and analyst during the winter of 1911-12.

Mr. O. J. Noer, Mr. Carl Thomson, and Mr. Alfred Buser have been employed during the present field season as field assistants.

In order to economize in the work of direction of the Survey and to secure a greater degree of unity in the work of the state and bureau members of the force, a coöperation has been arranged in the employment of Mr. W. J. Geib, who was originally placed in charge of the work of the bureau in the state. By this coöperation Mr. Geib will assist Mr. Whitson in the supervision of the work of the state members of the Survey and in the state's edition of the reports.

Mr. F. L. Musback, who has been in charge of the northwestern portion of the state during the past three years, has resigned his position on the Survey to accept the position of instructor in the department of soils, College of Agriculture, in which his work will be the supervision of the extension work

of that department in the area of which he has made the soil survey. The full knowledge of agricultural conditions which Mr. Musback has gained in making the soil survey of that region will be of immense value to him in the new position.

IV. PUBLICATIONS.

During the biennial period there have been issued the following publications:

Bulletin No. XXI. Scientific Series No. 6.

The Fossils and Stratigraphy of the Middle Devonian of Wisconsin. Herdman F. Cleland. Professor of Geology, Williams College. Pp. 206; 55 plates. 1911.

Bulletin No. XXII. Scientific Series No. 7.

The Inland Lakes of Wisconsin; the Dissolved Gases of the Water and their Biological Significance. Edward A. Birge and Chancey Juday. Pp. xxi, 254; 10 plates, 142 figures in text; all diagrams of gases and plankton. 1911.

Bulletin No. XXIII. Economic Series No. 14.

Reconnaissance Soil Survey of Part of Northwestern Wisconsin. S. Weidman, with the assistance of E. B. Hall and F. L. Musback. Pp. viii, 103; 15 plates, including one map; 16 figures in the text. 1911.

Bulletin No. XXIV. Economic Series No. 15.

Reconnaissance Soil Survey of Marinette County. Samuel Weidman and Percy O. Wood. Pp. 44, 4 plates, one map. 1911.

Several publications are in press or ready to go to the printer. The most important of these is the large geological and road map of the state, described earlier in this report. This is now almost ready to be issued. There is also in the press Bulletin No. XXV, Scientific Series No. 8: "The Sandstones of the Wisconsin Coast of Lake Superior," by F. T. Thwaites.

The following soil survey bulletins are in press: "Soil Survey of Waushara County," "Soil Survey of Waukesha County," "Soil Survey of Iowa County," "Soil Survey of the Bayfield Area."

Mr. Hatchkiss' report on the Florence iron district is nearly ready for the printer, as are also the educational bulletins men-

consin" (Bulletin XX), which covers these water powers so far as the funds provided permitted. There still remain many streams in the state concerning which there is no accurate information with regard to water power. In the list of still un-surveyed streams are found many of the larger rivers. Among these are the St. Croix, the upper Chippewa, the upper Wisconsin, the Wolf, Oconto, Menomonee, White, Bad, Trempealeau, and the La Crosse rivers. These streams should be surveyed carefully to determine the exact fall and just where the greatest amount of fall is located. Proper regulation in the interests of the public, and private owners as well, demands that no permit be given for the development of water power in the locality where it is going to make impossible later developments that might be much more advantageous, and this regulation requires more accurate knowledge of the stream profile and the topography of the valley than we have at present. Furthermore, the proper development of water power is very intimately dependent upon a knowledge of the stream flow, which can only be obtained from a long continued program of stream gauging; and moreover, topographical maps are also necessary for this purpose. For the proper development of water power, therefore, as well as for the regulation of dam construction from the idea of public safety, stream gauging and topographical maps are necessary, and the United States government is ready to put in dollar for dollar with the state in securing this information.

3. *Drainage.* The present drainage laws of the state result in very serious waste. Drainage districts are in general correctly outlined by nature, that is, a drainage district to be well planned must take in the whole area that can properly be drained through a single system. Failure to do this in many cases has resulted in one drainage organization digging a ditch covering the lower portion of the natural drainage system, and when the upper portion of the natural drainage system desired to develop its drainage, the adjustment of the fees to be charged by the lower district has resulted in litigation, which frequently has cost us as much as 50 per cent of the total sum invested in drainage. This great economic waste can only be obviated by careful regulation. No drainage district should be allowed to organize unless it comprises the whole of the natural drainage area. The determination of this requires careful surveys and topographical maps. Many states have provided funds for the

making of these topographical maps in conjunction with the United States geological survey. Since the areas which are to be drained in Wisconsin are very large, it is important that the legislature provide means whereby this information can be obtained, so that the present waste in litigation over drainage districts may be done away with so far as practicable. These topographical maps are the same as those mentioned under "Dam Regulation" and "Water Power", and the federal government will duplicate any reasonable sum which the legislature may appropriate.

4. Magnetic Survey. Recent developments in Northern Wisconsin have indicated that much territory can profitably be explored for iron ore. The region in which it is apparent that much exploration is going to be done is covered with a thick coating of glacial drift, and very little can be known with regard to the rocks, as they are exposed in so few places. A careful magnetic survey, however, will give a great deal of information with regard to the advisability of exploration for iron ore, and much money can be saved to the people who are undertaking these explorations, and much benefit to the state result by directing these explorations into places where they are most likely to be profitable. There are strong geological evidences that Northern Wisconsin contains undiscovered iron ranges and a survey should be made as rapidly as possible in order to develop this industry. Such surveys will take a number of years to complete, but would, undoubtedly, result in much benefit to the state.

B. NATURAL HISTORY.

The investigation of the lakes has hitherto been carried on with the aid of one assistant, Mr. Juday, the biologist of the Survey. Chemical work has been done as it was needed from time to time, by temporary assistance. The studies now going on require the time and the skill of a permanent chemist, and this condition will continue for several years. There is needed a chemist who can not only analyze accurately the materials submitted to him, but also one who can give time and study to the intricate problems which are offered by the chemistry of the living beings of a lake. The possibilities of our lakes for producing fish offer a great and complex question and one

whose answer must be reached very slowly. The Survey is now getting nearer to the central problems of this general question and these call for correspondingly more work and of more kinds.

The Survey, with the aid of the commissioners of fisheries, has now brought together a fairly large collection of the fishes of the state. If an adequate report is to be made upon this subject a considerable part of the time of an assistant, if not the whole time of one person, should be devoted to working up this collection.

C. SOILS.

As already stated, the work of the soil survey has progressed with reasonable rapidity and we shall in all probability be able to complete the work as outlined in our statement to the legislature in 1909 when the funds for the soil survey were allowed. There is, however, a large demand for more detailed maps of the northern portion of the state and for their preparation in a shorter time. If this demand seems to warrant it I believe a request should be made of the coming legislature for additional funds to meet this demand. While the detailed survey of the northern part of the state in its present undeveloped condition would be much more expensive than after development has taken place or than the present detailed survey in the southern part of the state, it would have an additional value in giving prospective purchasers more practical knowledge than is possible in the reconnoissance survey. There would be no duplication of the work, the reconnoissance survey serving as a basis for the more detailed mapping, should such be required.

PUBLICATIONS

OF THE

Wisconsin Geological and Natural History Survey.

The publications of the Survey are issued as (1) bulletins, which are numbered consecutively, (2) road pamphlets, (3) biennial reports, and (4) hydrographic maps. These publications are independently paged and indexed, no attempt being made to group them in volumes.

1. BULLETINS.

The bulletins are issued in three series:

Scientific Series.—The bulletins so designated consist of original contributions to the geology and natural history of the state, which are of scientific interest rather than of economic importance.

Economic Series.—This series includes those bulletins whose interest is chiefly practical and economic.

Educational Series.—The bulletins of this series are primarily designed for use by teachers and in the schools.

The following bulletins have been issued.

Bulletin No. 1. Economic Series No. 1

On the Forestry Conditions of Northern Wisconsin. Filibert Roth, Special Agent, United States Department of Agriculture. 1898. Pp. vi, 78; 1 map. *Out of print.*

Bulletin No. II. Scientific Series No. 1.

On the Instincts and Habits of the Solitary Wasps. George W. Peckham and Elizabeth G. Peckham. 1898. Pp. iv, 241; 14 plates, of which 2 are colored 2 figures in the text. Sold at the price of \$1.50 in paper and \$2.00 bound.

Bulletin No. III. Scientific Series No. 2.

A Contribution to the Geology of the Pre Cambrian Igneous Rocks of the Fox River Valley, Wisconsin. Samuel Weidman, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. iv, 63; 10 plates; 13 figures in the text. *Out of print.*

Bulletin No. IV. Economic Series No. 2.

On the Building and Ornamental Stones of Wisconsin. Ernest Robertson Buckley, Ph. D., Assistant Geologist, Wisconsin Geological and Natural History Survey. 1898. Pp. xxvi, 544; 69 plates, of which 7 are colored, and 1 map; 4 figures in the text. Sent on receipt of 30c.

Bulletin No. V. Educational Series No. 1.

The Geography of the Region About Devil's Lake and the Dalles of the Wisconsin, with some notes on its surface geology. Rollin D. Salisbury, A. M., Professor of Geographic Geology, University of Chicago, and Wallace W. Atwood, B. S., Assistant in Geology, University of Chicago. 1900. Pp. x, 151; 38 plates; 47 figures in the text. *Out of print.*

Bulletin No. VI. Economic Series No. 3. Second Edition.

Preliminary Report on the Copper-Bearing Rocks of Douglas County, and parts of Washburn and Bayfield Counties, Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1901. Pp. vi, 83; 13 plates. Sent on receipt of 10c.

Bulletin No. VII. Economic Series No. 4.

The Clays and Clay Industries of Wisconsin. Part I. Ernest Robertson Buckley, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1901. Pp. xii, 304; 55 plates. Sent on receipt of 20c.

Bulletin No. VIII. Educational Series No. 2.

The Lakes of Southeastern Wisconsin. N. M. Fenneman, Ph. D., Professor of General and Geographic Geology, University of Wisconsin. 1902. Pp. xv, 178; 36 plates, 38 figures in the text. A second edition has been issued and will be sold at the price of 50c.

Bulletin No. IX. Economic Series No. 5.

Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1903. Pp. viii, 103; 2 maps, 2 plates, 8 figures in the text. *Out of print.*

Bulletin No. X. Economic Series No. 6.

Highway Construction in Wisconsin. Ernest Robertson Buckley, Ph. D., State Geologist of Missouri, formerly Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. xvi, 339; 106 plates, including 26 maps of cities. Sent on receipt of 30 cents.

Bulletin No. XI. Economic Series No. 7. Second Edition.

Preliminary Report on the Soils and Agricultural Conditions of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1903. Pp. viii, 67; 10 plates, including soil map. Second edition, 1908. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XII. Scientific Series No. 3.

The Plankton of Lake Winnebago and Green Lake. C. Dwight Marsh, Ph. D., Professor of Biology, Ripon College. 1903. Pp. vi, 94; 22 plates. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIII. Economic Series No. 8.

The Baraboo Iron-bearing District of Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. 1904. Pp. x, 190; 23 plates, including geological map. Sent, paper bound, on receipt of 10 cents.

Bulletin No. XIV. Economic Series No. 9.

Report on Lead and Zinc Deposits of Wisconsin. Ulysses Sherman Grant, Ph. D., Professor of Geology, Northwestern University. 1906. Pp. ix, 100; 8 plates; 10 figures in the text; an atlas containing 18 maps; and a supplementary atlas containing 6 maps; issued in 1909. *Out of print.*

Bulletin No. XV. Economic Series No. 10.

The Clays of Wisconsin and Their Uses. Heinrich Ries, Ph. D., Assistant Professor of Economic Geology, Cornell University. 1906. Pp. xii, 259; 30 plates, including 2 maps; 7 figures in text. Sent on receipt of 18 cents.

Bulletin No. XVI. Scientific Series No. 4.

The Geology of North Central Wisconsin. Samuel Weidman, Ph. D., Geologist, Wisconsin Geological and Natural History Survey. Pp. xxxi, 697; 86 plates, including 2 maps; 38 figures in the text. 1907. Sent on receipt of 40 cents.

Bulletin No. XVII. Scientific Series No. 5.

The Abandoned Shore-lines of Eastern Wisconsin. J. W. Goldthwait, Ph. D., Assistant Professor of Geology, Northwestern University. Pp. x, 134; 38 plates; 37 figures in the text. 1907. Sent on receipt of 15 cents.

Bulletin No. XVIII. Economic Series No. 11.

Rural Highways of Wisconsin. W. O. Hotchkiss, B. S., Instructor in Geology, University of Wisconsin; in charge of Economic Geology, Wisconsin Geological and Natural History Survey. 1906. Pp. xiv, 135; 16 plates; 2 figures in the text. Sent on receipt of 10 cents.

Bulletin No. XIX. Economic Series No. 12.

Zinc and Lead Deposits of the Upper Mississippi Valley. H. Foster Bain. Director of State Geological Survey of Illinois. Washington, D. C. 1907. Pp. xii, 155; 9 plates, including 5 maps; 45 figures in the text. Sent on receipt of 6 cents.

This bulletin is a reprint of Bulletin No. 294 of the United States Geological Survey. Only a small number of copies were reprinted for local use. It has not been sent out to libraries and exchanges.

Bulletin No. XX. Economic Series No. 13.

The Water Powers of Wisconsin. L. S. Smith, C. E.; Engineer Wisconsin Geological and Natural History Survey; Engineer U. S. Geological Survey. Pp. xvi, 354; 54 plates; 17 figures in the text. 1908. *Out of print.*

Profile maps of the Wisconsin river were issued by the United States Geological Survey, based on coöperative work with the Wisconsin Survey. The stock of these maps is now deposited with this Survey and the maps will be sent on the same terms as they were by the U. S. Survey, viz.: 5 cents per sheet, postpaid. There are eleven maps in this series.

Bulletin No. XXI. Scientific Series No. 6.

The Fossils and Stratigraphy of the Middle Devonian of Wisconsin. Herdman F. Cleland. Professor of Geology, Williams College. Pp. 206; 55 plates. 1911. Sent on receipt of 25 cents.

Bulletin No. XXII. Scientific Series No. 7.

The Inland Lakes of Wisconsin; the Dissolved Gases of the Water and their Biological Significance. Edward A. Birge and Chauncey Juday. Pp. xxi, 254; 10 plates, 142 figures in text; all diagrams of gases and plankton. 1911. Sent on receipt of 25 cents.

Bulletin No. XXIII. Economic Series No. 14.

Reconnaissance Soil Survey of Northwestern Wisconsin. S. Weidman, with the assistance of E. B. Hall and F. L. Musback. Pp. viii, 103; 15 plates, including one map; 16 figures in the text. 1911. Sent, paper bound, on receipt of 10 cents; cloth bound, 20 cents.

Bulletin No. XXIV. Economic Series No. 15.

Reconnaissance Soil Survey of Marinette County. Samuel Weidman and Percy O. Wood. Pp. 44; 4 plates, one map. 1911.

Bulletin No. XXV. Scientific Series No. 8.

Sandstones of the Wisconsin Coast of Lake Superior. Fredrik Turville Thwaites. Pp. viii, 117; 23 plates; large map in pocket; 10 figures in text. 1912. Cloth bound. Sent on receipt of 20 cents.

Bulletin No. XXVI. Educational Series No. 3.

The Geography and Industries of Wisconsin. R. H. Whitbeck. Pp. viii, 65; 23 plates; 46 figures in the text. 1913. Cloth bound. Sent on receipt of 12 cents.

ROAD PAMPHLETS.

Road Pamphlet No. 1.

Earth Roads. Arthur R. Hirst, B. S., Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 26; 13 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 2.

The Earth Road Drag. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 16; 4 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 3.

Stone and Gravel Roads. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 27; 11 figures. Sent on receipt of 2c postage.

Road Pamphlet No. 4.

Culverts and Bridges. Arthur R. Hirst, B. S. Highway Engineer, Wisconsin Geological and Natural History Survey. Pp. 47; 16 figures. Sent on receipt of 2c postage.

2. BIENNIAL REPORTS.

The Survey has published eight biennial reports, which relate to administrative affairs only and contain no scientific matter.

First Biennial Report of the Commissioners of the Geological and Natural History Survey. 1899. Pp. 31.

Second Biennial Report of the Commissioners of the Geological and Natural History Survey. 1901. Pp. 44.

Third Biennial Report of the Commissioners of the Geological and Natural History Survey. 1903. Pp. 35.

Fourth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1904. Pp. 42.

Fifth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1907. Pp. 45.

Sixth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1909. Pp. 45

Seventh Biennial Report of the Commissioners of the Geological and Natural History Survey. 1911. Pp. 55.

Eighth Biennial Report of the Commissioners of the Geological and Natural History Survey. 1912. Pp. 38.

4. HYDROGRAPHIC MAPS.

There have been prepared hydrographic maps of the principal lakes of southern and eastern Wisconsin. This work is in charge of L. S.

Smith, C. E., Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin.

The maps are as follows:

		Size of Plate, Inches.	Scale. Inches per mile.	Contour. Inter- val, feet.
No. 1.	Lake Geneva.....	17.5x10.8	2	10
No. 2.	Elkhart Lake.....	15.5x13.1	5	10
No. 3.	Lake Beulah.....	22.5x20.0	6	10
No. 4.	Oconomowoc-Waukesha Lakes.....	29.8x19.1	2	10
No. 5.	The Chain of Lakes, Waupaca.....	21.7x20.6	6	10
No. 6.	Delavan and Lauderdale Lakes.....	22.5x16.8	4	10
No. 7.	Green Lake.....	26.0x17.8	3.2	20
No. 8.	Lake Mendota.....	23.7x19.5	6	5
No. 9.	Big Cedar Lake.....	18.0x13.5	2.9	10
No. 10.	Lake Monona.....	17.6x17.3	4	5

In all of these maps the depth of the lakes is indicated by contour lines, and by tints in all except No. 1. They are sent on receipt of 10 cents each and may be had either mounted in a manilla cover, or unmounted.

GEOLOGICAL MODEL OF WISCONSIN

The Survey has prepared a model which shows in great detail the topography of the state. It is designed for use in schools, libraries, and similar public institutions, and is 49 inches by 45 inches in size. It is supplied to such institutions in Wisconsin at the cost of labor and materials used in its construction. The form showing topography alone is furnished for \$31 and the form showing geology in addition to topography is furnished for \$46. A special circular with illustration of the model may be had on application.

GEOLOGY AND ROAD MAP OF WISCONSIN.

A geological map of the state has been prepared and is now on sale. This is a large wall map 54 inches wide and 62 inches long. It shows all the roads of the state and the geology. The main travelled roads between cities are prominently shown by a red color. All counties, cities, villages, towns, Indian Reservations, railroad lines, rivers and lakes are shown. In the corners of the map are the legend, which gives the name, character and thickness and economic products of the various geologic formations; an outline of the geologic history of the state; and a table of elevations of the prominent physiographic features of the state. At the bottom are three sections showing the geologic structure. Under authority of the legislature this map is distributed to all the schools of the state by the state superintendent of Public Instruction. The map is sold to other persons by the state at the cost of printing, and can only be obtained from the Superintendent of Public Property. With substantial cloth mounting and roller and stick at bottom and top, the price is \$1.00. The folded paper map suitable for sectional mounting is sold for 30 cents.

SOIL REPORTS.

The United States department of agriculture has issued a report on the soils of Waushara county, prepared by the Wisconsin Survey and the United States bureau of soils. Similar reports are in press regarding the soils of Iowa, Marinette, and Waukesha counties. State editions of these reports will be issued later. These will contain chemical analyses of soils and other data which are not given in the reports published by the bureau of soils. The state editions will be distributed widely in the counties interested.

All correspondence relating to the Survey should be addressed to

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Madison, Wis.

or to

W. O. HOTCHKISS, *State Geologist,*

Madison, Wis.

